File Transfer over Dual-Stack IPv6 Tunnelling in Real Network Environment: Router to Router Performance Analysis Using Best Effort Approach

Mohd Nazri, Ismail[1], Mohd Hafizh, Mohamed[2]
[1]Department of Science and Defence Technology
National Defence University of Malaysia (UPNM)
Malaysia
[2]MIIT, University of Kuala Lumpur (UniKL)
Malaysia
mnazri4@yahoo.com, mhafizh@miit.unikl.edu.my

ABSTRACT: *In this research, we propose an architectural solution to implement file transfer service (FTP) in IPv6 environment network. IPv6 is considered to be the next-generation Internet protocol. Thus, this study is to analyze the size of files transfer performance and to measure Quality of Service (QoS) delivered by IPv6 using best effort approach in comparison to IPv4. This study primarily focuses on file transfer speed quality of FTP. In the experiment, both host clients and routers utilize the same technical specification. In the same study also, network management system (NMS) is used to monitor and to capture the performance of file transfer in IPv6 and IPv4 environment. Based on the finding result, it shows that there is a slight but significant difference in file transfer performance between dual stack tunnelling IPv4 and IPv6 protocol. Small size file transfer will result in lower and same delay performance outcome for both IPv4 and IPv6, while large size file transfer over IPv6 will result in higher delay performance as compared to IPv4. In short, the significant result of IPv6 delay is slightly higher than IPv4. Hence, the quality of FTP might be decreased if dual stack tunnelling is implemented in IPv6 environment. Nevertheless, Link Efficiency and compression technique are able to lower the delay performance on file transfer over IPv6 environment.*

Keywords: FTP, IPv6, Delay, Performance, IPv4

Received: 12 October 2013, Revised 14 October 2013, Accepted 20 October 2013

1. Introduction

The File Transfer Protocol (FTP) was one of the main protocols widely used by the Internet. It was designed to enable files delivery process over a Transmission Control Protocol/Internet Protocol (TCP/IP) network, whether it is IP version 4 (IPv4) or IP version 6 (IPv6) network [15], [16].

IPv6 is proposed by IEFT to provide the Internet with larger address space and better performance [1]. In the past ten years, a lot of works have been done on the protocol design [4], connection and routing mechanism [5], [6], [7], and transition mechanisms [8], [9] of IPv6. As the demand of IPv6-supported network equipments increases, some performance evaluation methods and platforms are proposed, which mainly focus on the performance of hardware and its compatibility with IPv6 protocols [10],[11]. (Yi Wang).

Many studies on IPv6 performance have been conducted previously. Some focus on SIP performance with IPv6, while others are concerned with IPv6-IPv4 transition issues [8].

Much works have been done on IPv6 standards and many IPv6 testbeds have been deployed. However, little is known about the performance of the real IPv6 Internet, especially from the perspective of end users [16].

Today, a lot of large files are being transferred across the Internet as part of daily working process [17] or as needs to fulfil social and entertainment live. Future network which will be based on richer multimedia content [18], [19], will introduce new challenges and require higher network bandwidth.

As with most new technologies, IPv6 environment brings new challenges along with the benefits, but very few researchers had evaluated its effectiveness in terms of the campus network IPv6 environment. Most research had only focus on implementation of IPv4 environment.

According to [15], testbed with network switch and router for IPv4 and IPv6 should be conducted in real network environment. Therefore, this study will focus on the file transfer between router to router in campus network environment using dual-stack IPv6 tunnelling best effort approach.

IPv6 can improve the Internet or Intranet, with benefits such as:

• Expanded addressing capabilities;

• Server requires less auto configuration (plug-and-play) and reconfiguration;

• End-to-end security, with built-in, strong IP-layer encryption and authentication; and

• Enhanced support for multicast and QoS.

This paper presents the evaluation of dual-stack IPv6 tunneling performance based on the time taken to transmit the size of file to the intended destination/party. The objectives of this study are:-

i. To study the characteristics of file transfer over dual stack IPv6 tunnelling performance.

ii. To study the implementation and configuration of dual stack IPv6 tunnelling between router to router.

The contributions of this study are:-

i. To produce a significant knowledge on file transfer over dual stack IPv6 tunnelling implementation on social network particularly for researchers and institutions of IPv6 groups.

ii. The results of the file transfer performance over dual stack IPv6 tunnelling between router to router are useful and valuable as they can be used as a guidelines for ISPs in next generation network.

2. Related Works

Recently, VoIP (Voice over IP) [1] is rapidly growing and becoming a mainstream telecommunication services, it is also convergence technologies of data and voice communication. There have been numerous studies on VoIP measurement. A. Markopoulou [3] measured loss and delay characteristics of American backbone networks, and analyzed how these characteristics impact VoIP quality. For example, most work focused on monitoring and analyzing performance of actual applications, like MSN and Skype [2], [4], [5], [6].

In [7], an architecture based on SIP for integrating VoIP components in IPv4 and IPv6 networks is proposed. The authors note that based on studies using testbed, while the IPv6-capable SIP server (SER) and SIP IPv4-IPv6 gateway (mini-SIP-proxy) performed their functions well and the Cisco IP phone and X-Lite softphone used for IPv4 calls from/to an IPv6 user agent IPv4 were adequate, the audio quality of the IPv6 softphone used was not satisfactory in many cases [8].

IPv6 is still in its infancy stage and it is hardly ever used by real-life applications, while there is a lack of knowledge about the network performance of end-to-end IPv6 communication [9]; [10]; [11]. For example, a case study has been conducted on different types of operating system using IPv6 protocol. However, only a few works have been presented to evaluate the performance of IPv6 protocol [12]. In [13], a performance comparison of IPv6 with respect to Windows 2003, Redhat Linux 9.0 and FreeBSD 4.9 is presented. Measurement of throughput and roundtrip time with TCP and UDP for small (32-1500 bytes) and large (8192 bytes – 64 KB) files sizes show that Linux performs better than the other two operating systems [8], [14]. Thus, in order to provide high quality service for future Internet applications, insight in IPv6 performance measurements is needed.

3. Methodology

Figure 2 shows the overall framework of the dual stack IPv6 study on router devices. There are five development processes as follow: i) planning and research; ii) development; iii) implementation; iv) testing and v) documentations. Besides, file transfer over IPv4 protocol environment is used as our test-bed to compare with file transfer over dual stack IPv6 tunnelling environment.

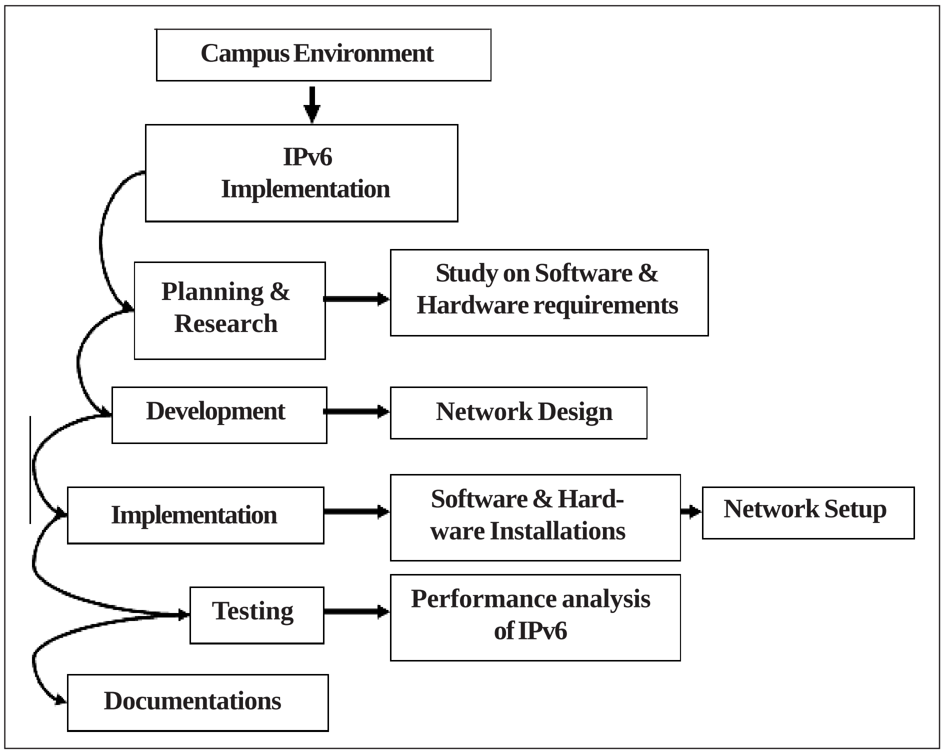


Figure 2. Dual Stack IPv6 Tunnelling Implementation Framework

Figure 3 shows the technical framework of dual stack IPv6 tunnelling and performance analysis on router. In the experiment, the performance analysis will focus on delay (time taken packet transfer to destination) occurs on router to router. Network management system such as ‘*card capture counter*’ is used to analyze the performance of file transfer over dual stack IPv6 tunnelling environment.

4. Proposed Dual Stack Ipv6 Tunneling Implementation on Router

We have setup a real file transfer over dual stack IPv6 tunnelling in campus network environment at University of Kuala Lumpur. This study posits several research questions: i) what is the performance level of the file transfer over dual stack IPv6 tunnelling; and ii) Is the analysis for evaluating and measuring file transfer over dual stack IPv6 tunnelling performance effective. Figure 4 shows the implementation of dual stack IPv6 tunnelling architecture between router to router in real campus network environment. Dual stack IPv6 tunnelling quality can be monitored periodically through the measurement using Card Packet Counter management tools. Figure 5 and Figure 6 show the file transfer analysis performance that will be conducted and compared with IPv6 and IPv4.

Figure 7, Figure 8 and Figure 9 show this study has defined IPv6 and IPv4 configuration parameters on the Cisco router 1, router 2 serial ports and hosts such as gateway and Ethernet interface. Figure 10 and Figure 11 show the complete configuration system on Router 1 (R1) and Router 2 (R2) to enable dual stack IPv6 tunnelling and both routers have the same specification.

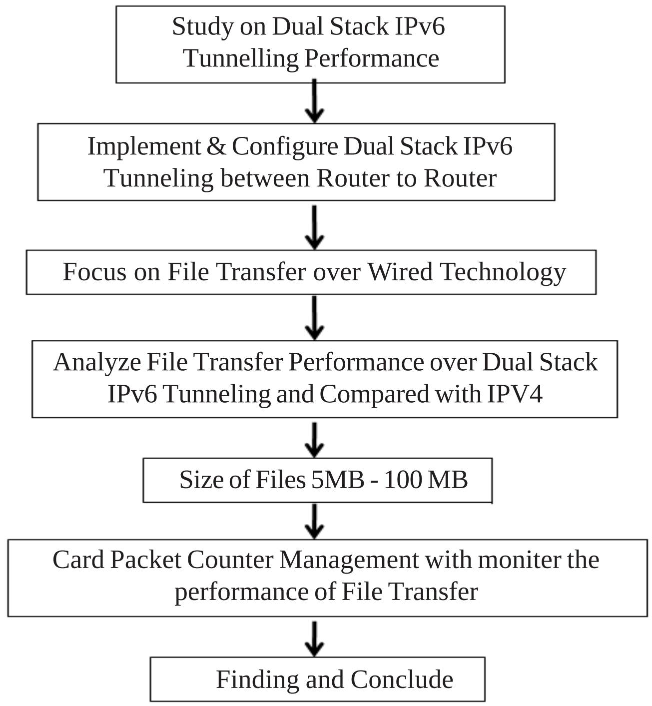


Figure 3. Technical Framework of Dual Stack IPv6 Tunnelling and Performance Analysis on Router

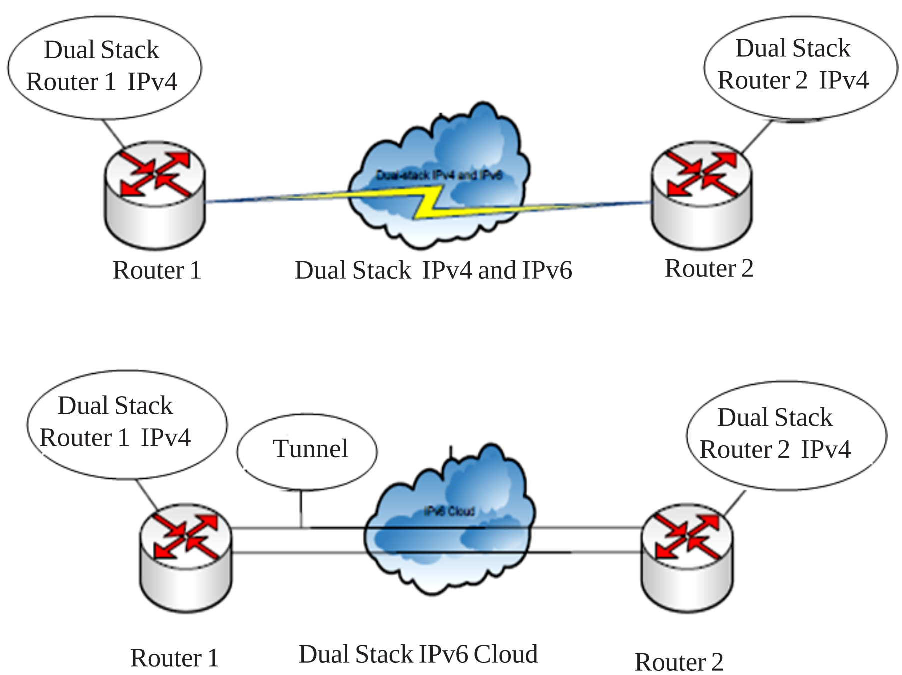


Figure 4. Implementation of Dual Stack IPv6 Tunnelling in Real Network Environment

5. Experimental and Analysis Results

This section measures, analyzes and compares dual stack IPv6 and IPv4 performance using best effort approach. This study

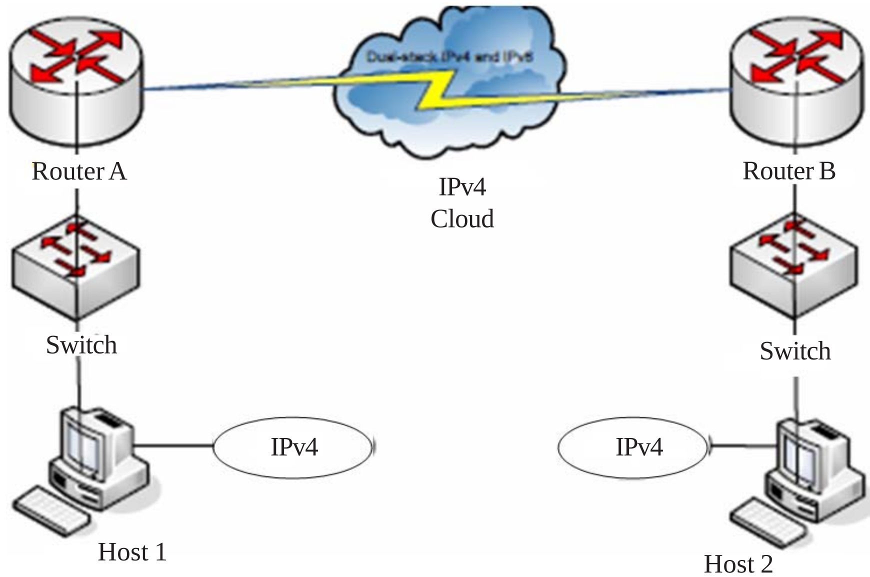


Figure 5. File Transfer - Communication Host 1 to Host 2 between Router to Router over IPv4

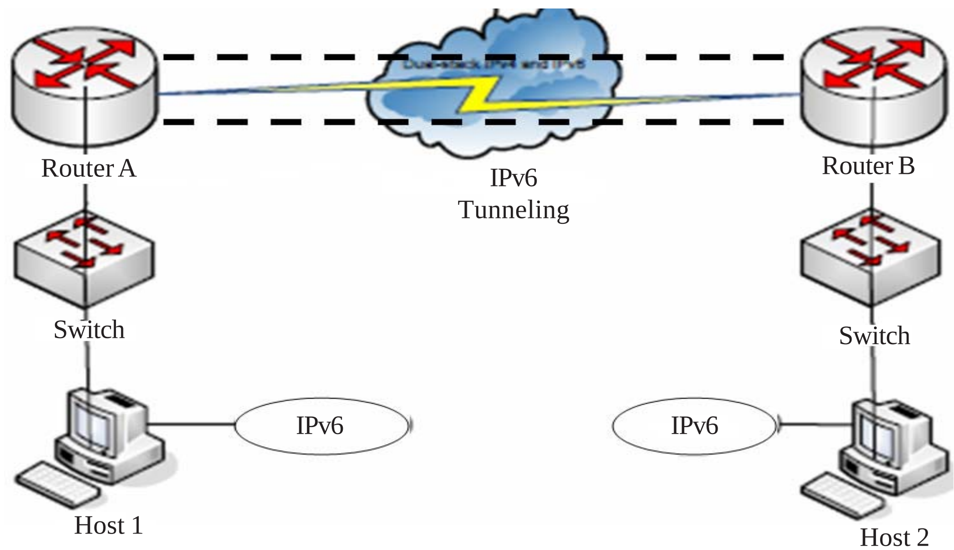


Figure 6. File Transfer - Communication Host 1 to Host 2 between Router to Router over IPv6 Tunnelling

has used two network management tools to capture and to analyze the performance of FTP over dual stack IPv6 and IPv4 such as Colasoft Capsa and Card Packet Counter.

In this study, FTP software (FileZilla) is used to transfer data via IPv6 and IPv4 environment. The FileZilla server will be installed on host 1 and host 2 with the same specification (refer to Table 1). Host 1 will receive the data from host 2. The size of data to be transferred between hosts in Megabyte (MB) (please refer to figure 12).

5.1 Experiment on FTP dual stack tunnelling over IPv6 and IPv4 performance analysis

This section will discuss about the performance analysis on the size of file transfer data over dual stack tunnelling over IPv6 as compared to IPv4 protocol. For the purpose of this experiment, we have divided the data into three different categories or sizes, for example, i) small size data (5 MB); ii) medium size data (30 MB); large size data (100 MB). In the experiment, we will examine the behaviour and trend of file transfer over dual stack tunnelling over IPv6 in comparison to IPv4. From the analysis, it is evident that file transfer over IPv4 (refer to Figure 13, Figure 14 and Figure 15) has produced similar behaviour and trend as file transfer activities over IPv6 environment (refer to Figure 16, Figure 17 and Figure 18). Therefore, file transfer over IPv4

Configuration on Router 2 (R1) dual-stack IPv4		
Interface	**IPV4 address**	**IPV6 address**
Fastetethernet	172.16.10.1	2001:420:ffff:a::1/64
Serial0/0/1	172.16.20.1	3ffe:b00:ffff:2::2/64
Host 1	172.16.10.10	2001:420:ffff:a::2/64

Configuration on Router 2 (R2) dual-stack IPv4		
Interface	**IPV4 address**	**IPV6 address**
Fastetethernet	172.16.30.1	3ffe:b00:ffff:3::1/64
Serial0/0/1	172.16.20.2	3ffe:b00:ffff:2::1/64
Host 2	172.16.30.30	3ffe:b00:ffff:3::2/64

Figure 7. Configuration Parameters: Dual-Stack IPv4 on Router 1 and Router 2

Configuration on Router 1(R1) dual-stack IPv6		
Interface	**IPv4 address**	**IPv6 address**
Fastethernet0/0	172.16.10.1	2001:420:ffff:a::1/64
Serial0/0/1	172.16.20.1	3ffe:b00:ffff:2::2/64
Tunnel	-	2001:1111:1111:1111::1/128
Host 1	172.16.10.10	2001:420:ffff:a::2/64

Configuration on Router 1(R1) dual-stack IPv6		
Interface	**IPv4 address**	**IPv6 address**
Fastethernet0/0	172.16.30.1	3ffe:b00:ffff::3:1/64
Serial0/0/1	172.16.20.2	3ffe:b00:ffff:2::1/64
Tunnel	-	2001:1111:1111:1111::1/128
Host 1	172.16.30.30	3ffe:b00:ffff:3::2/64

Figure 8. Configuration Parameters: Dual-Stack IPv6 on Router 1 and Router 2

Dual-host 1	Dual-host 2
IPv4 = 172.16.10.10	IPv4 = 172.16.30.30
IPv6 = 2001:420:ffff:a::1/64	IPv6 = 3ffe:b00:ffff:3:2/64

Figure 9. Configuration on the host 1 and host 2 for the dual host configuration

Hardware	Description
Intel Central Processing Unit (CPU)	CPU Intel Core 2 Duo 3.0 GHz
Kingston Random Access Memory (RAM)	3GB DDR2
Network Card	TP/Link 100mbps
Motherboard	MSI 220 appendices system build in VGA card

Table 1. Server Specification

```
R1#sh run
Building configuration...
hostname R1
ip cef ipv6 unicast-routing
ipv6 cef
interface Tunnel1
no ip address
ipv6 address 2002:1111:1111:1111::1/128
ipv6 enable
ipv6 router isis area1
tunnel source Serial0/0/1
tunnel destination 172.16.20.2
tunnel mode gre ipv6
interface FastEthernet0/0
no ip address
duplex auto
speed auto
ipv6 address 2001:420:FFFF:A::1/64
ipv6 enable
ipv6 router isis area1
interface Serial0/0/1
 no ip address
ipv6 address 3FFE:B00:FFFF:2::2/64
ipv6 enable
ipv6 router isis area1
router isis area1
```

Figure 10. Complete Dual Stack IPv6 Tunnelling Configuration on Router 1

```
R2#sh run
Building configuration...
hostname R2
ip cef ipv6 unicast-routing
ipv6 cef
interface Tunnel1
no ip address
ipv6 address 2002:1111:1111:1111::2/128
ipv6 enable
ipv6 router isis area1
tunnel source Serial0/0/1
tunnel destination 172.16.20.1
tunnel mode gre ipv6
interface FastEthernet0/0
no ip address
duplex auto speed auto
ipv6 address 3FFE:B000:FFFF:3::1/64
ipv6 enable
ipv6 router isis area1
interface Serial0/0/1
no ip address
ipv6 address 3FFE:B00:FFFF:2::1/64
ipv6 enable
ipv6 router isis area1
clock rate 2000000
router isis area1
```

Figure 11. Complete Dual Stack IPv6 Tunnelling Configuration on Router 2

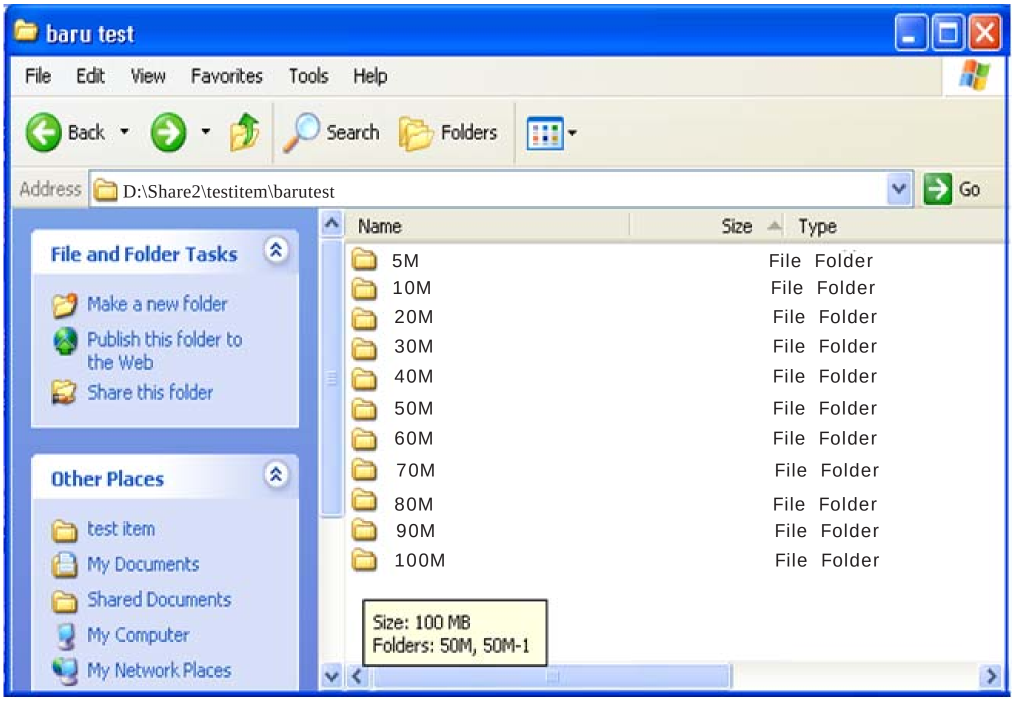


Figure 12. Size of File Transfer Data

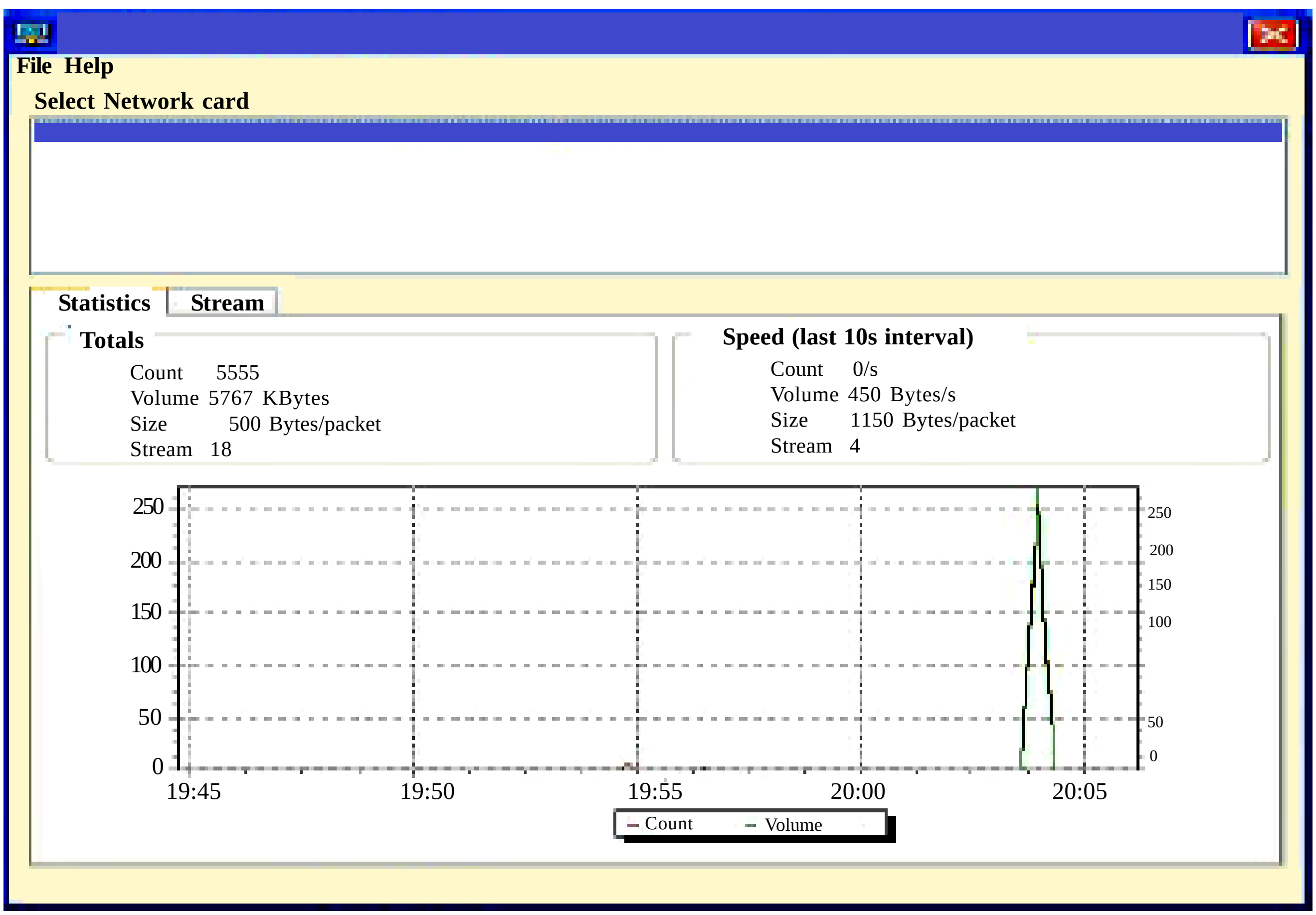


Figure 13. Small Size of Data - 5MB File Transfer over IPv4

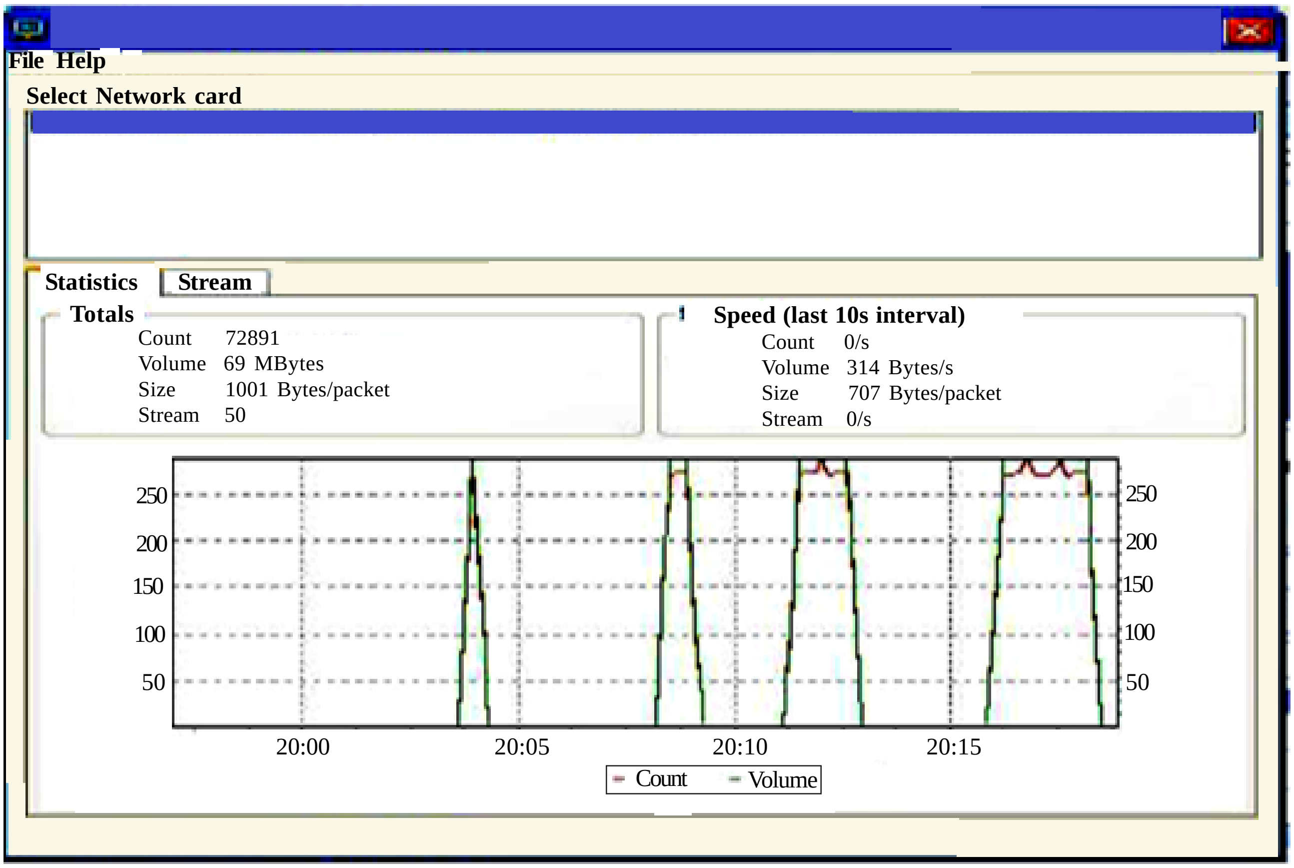


Figure 14. Medium Size of Data - 30MB File Transfer over IPv4

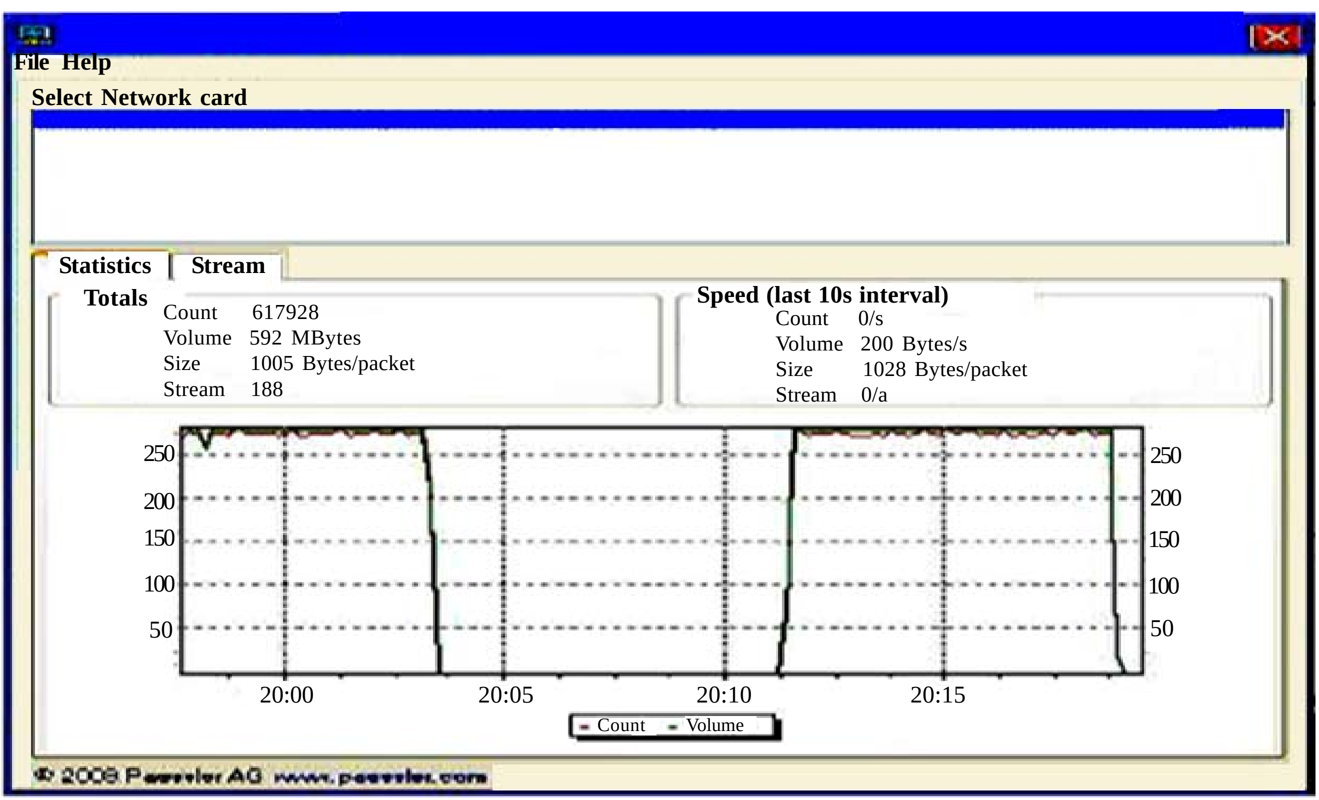


Figure15. Large Size of Data - 100MB File Transfer over IPv4

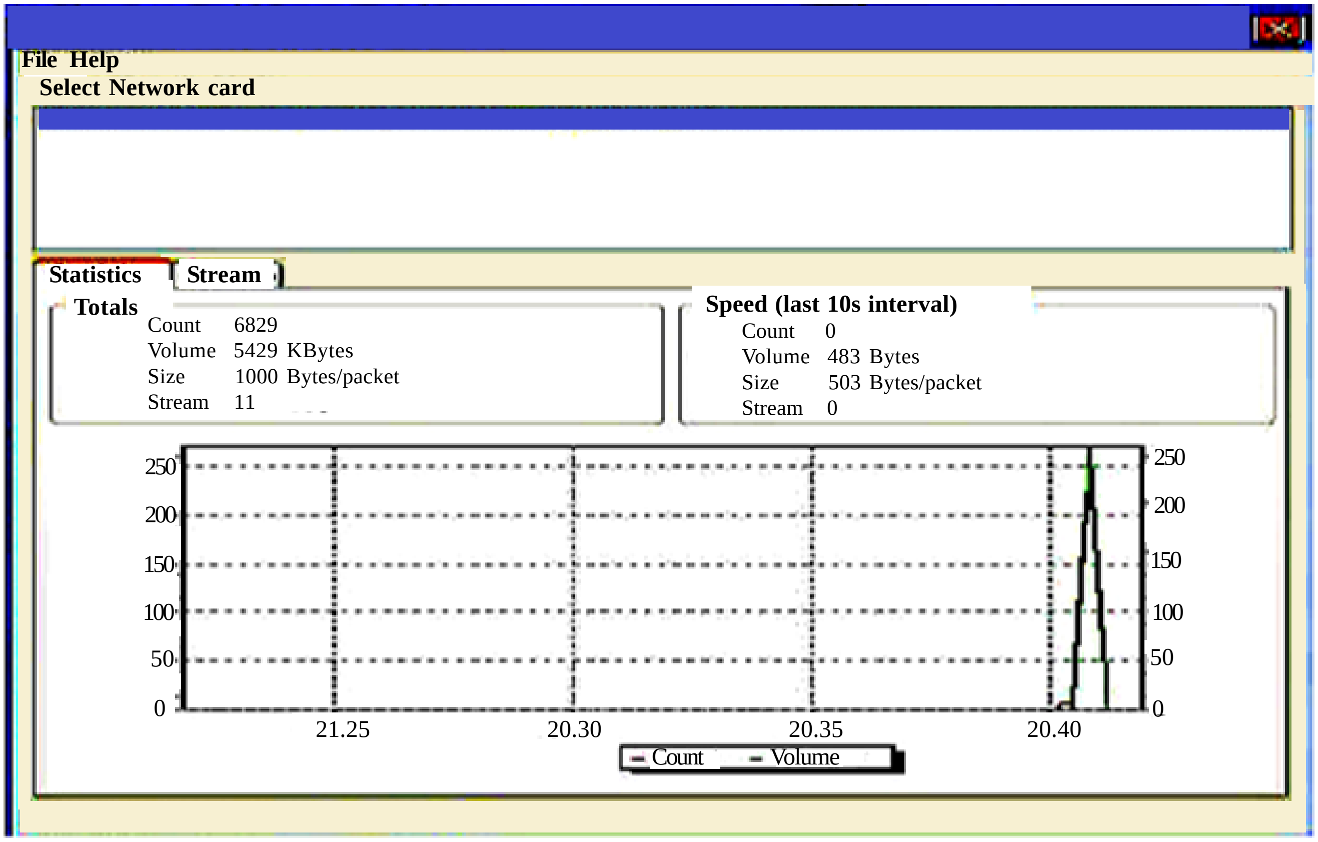


Figure 16. Small Size of Data - 5MB File Transfer over IPv6

Figure 17. Medium Size of Data - 30MB File Transfer over IPv6

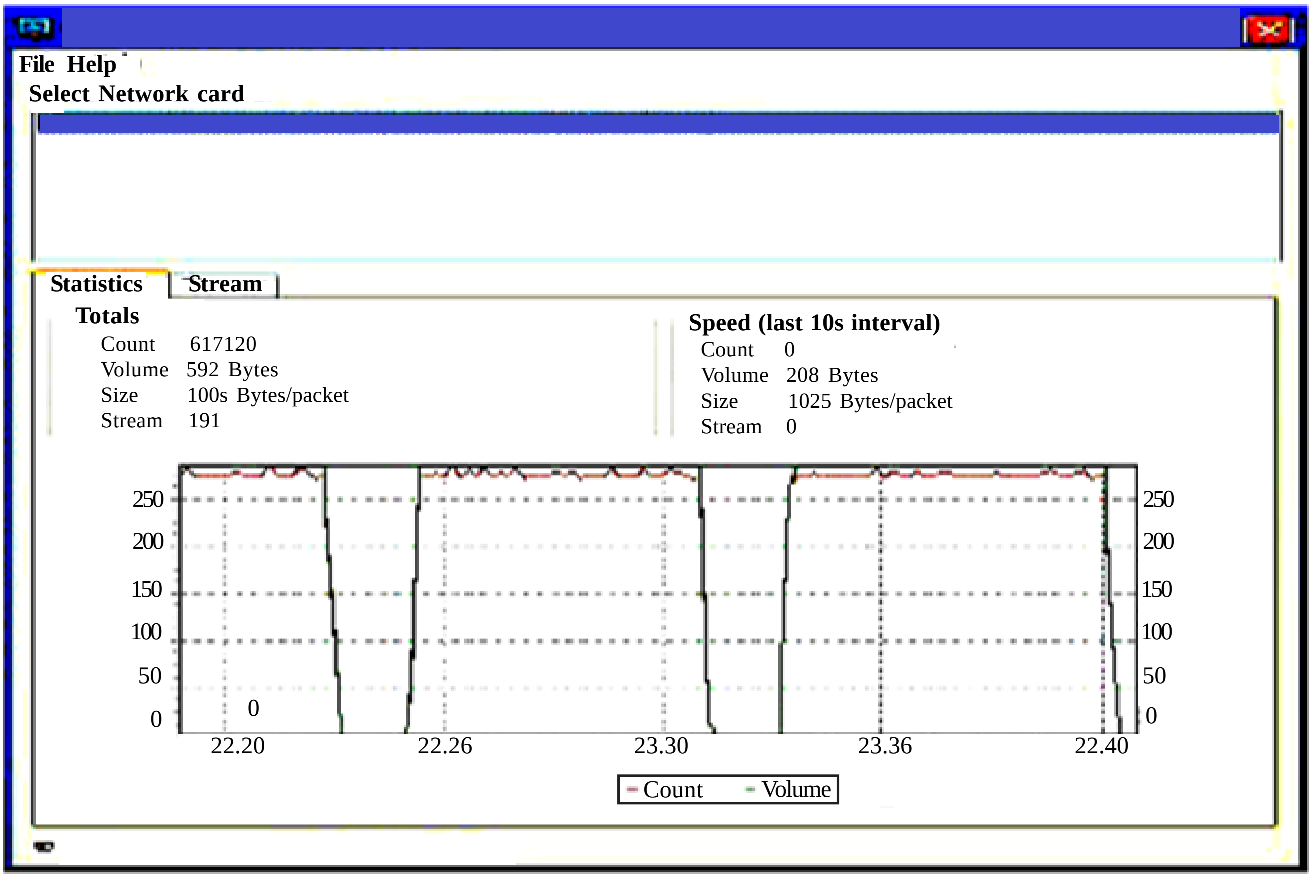


Figure 18. Large Size of Data - 100MB File Transfer over IPv6

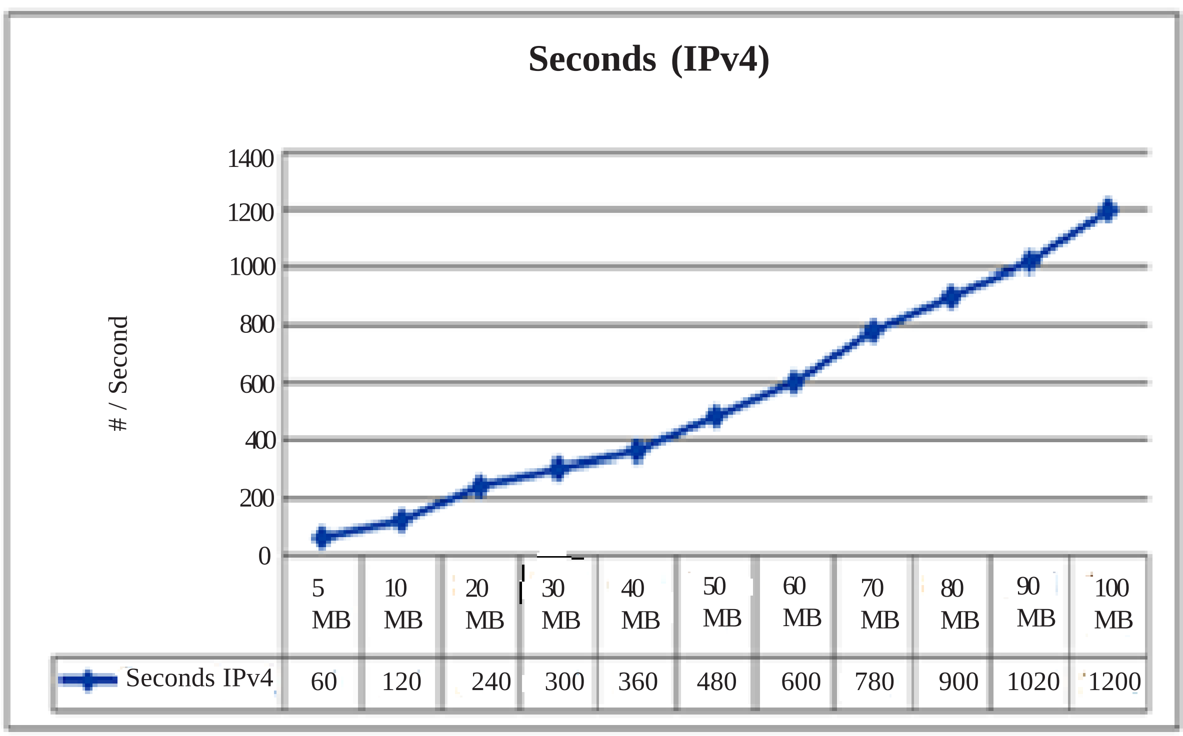
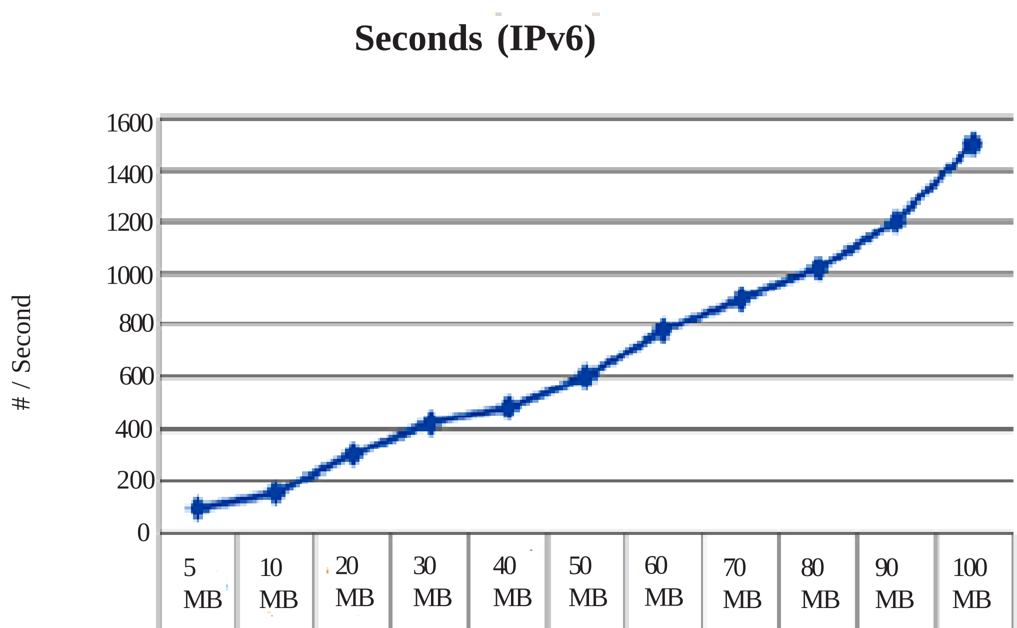
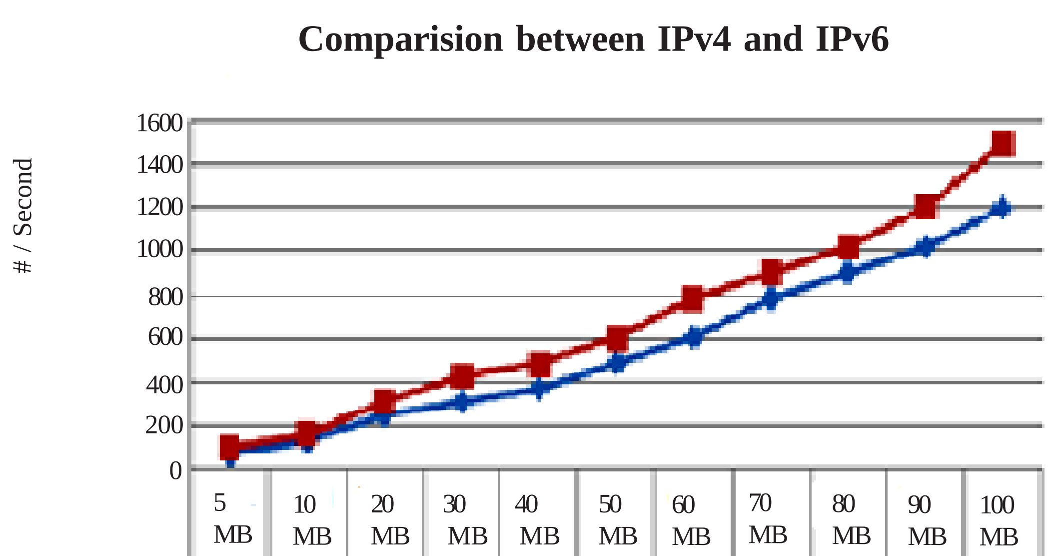


Figure19. Size of File Transfer over IPv4 Analysis Performance



	5 MB	10 MB	20 MB	30 MB	40 MB	50 MB	60 MB	70 MB	80 MB	90 MB	100 MB
Seconds IPv6	90	150	300	420	480	600	780	900	1020	1200	1500

Figure 20. Size of File Transfer over IPv6 Performance Analysis



	5 MB	10 MB	20 MB	30 MB	40 MB	50 MB	60 MB	70 MB	80 MB	90 MB	100 MB
Seconds IPv4	60	120	240	300	360	480	600	780	900	1020	1200
Seconds IPv6	90	150	300	420	480	600	780	900	1020	1200	1500

Figure 21. Comparison - Size of File Transfer over IPv6 and IPv4 Performance Analysis

and IPv6 does not display much difference for both protocols, although there is a difference in terms of speed performance (delay). In addition, it is also found that the implementation of dual stack IPv6 affect the performance of FTP speed during file transfer activities.

0 bits	4	8	16	24	31
Version	IHL	Service Type	Total length		
Identifier			Flags	Fragment Offset	
Time to Live		Protocol	Header Checksum		
Source Address(32 bit)					
Destinatio Address(32 bit)					
Option and Packing					

IPv4 Header

Version	Class	Flow Label	
Payload Length		Next Header	Hop Limit
Source Address (128 bit)			
Destinatio Address 128 bit			

IPv6 Header

Figure 22. Size of Packet Header IPv4 and IPv6

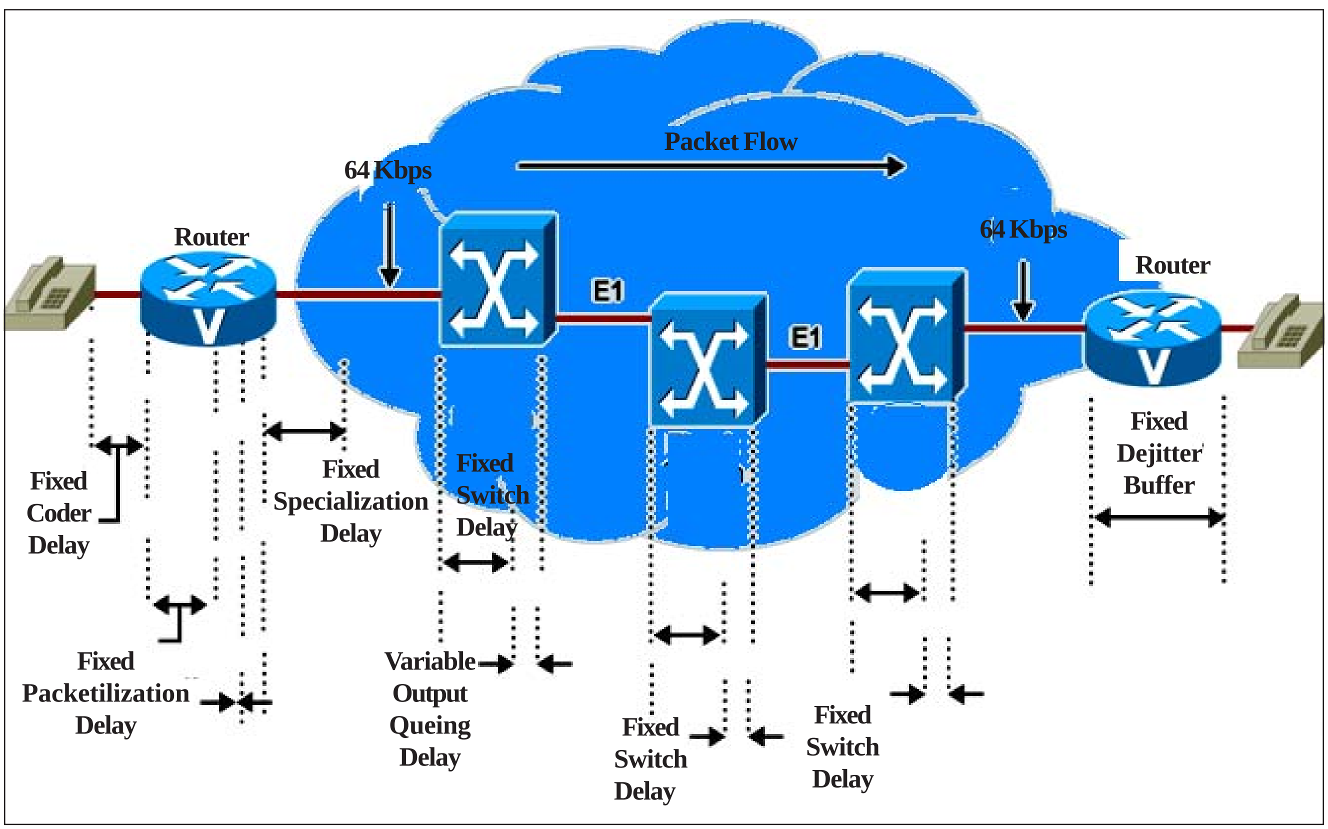


Figure 23. Number of Hops: File Transfer over IPv6 Protocol

5.2 Overall results – Dual stack tunnelling IPv6 in comparison to IPv4 protocol

In this section, we have summarised all the results based on the size of file transfer, which was from 5MB to 100MB, over IPv6 and IPv4. From the results gathered, it can be seen that IPv6 protocol has generated higher level of delay in comparison to IPv4 during files transfer (refer to Figure 19, Figure 20 and Figure 21). Furthermore, the size of file transfer data itself also affects the speed performance on both IPv6 as well as on IPv4 (refers to Figure 19, Figure 20 and Figure 21).

There are few factors which can affect and lower FTP performance during file transfer over dual stack tunnelling IPv6 in comparison to IPv4, which are:

i) Size of packet header – The size of packet header for IPv6 is much larger than IPv4 protocol (refer to figure 22). Hence, the implementation of IPv6 introduces concerns which are related to expanded packet headers. In this case, the packet header size of IPv4 is doubled from 20 Bytes to at least 40 Bytes of IPv6.

ii) Number of hops – Number of hops also will affect and lower FTP performance when the size of files traverse along the network path to the intended destination/party (refer to figure 23). The implementation of FTP over dual stack tunnelling over IPv6 should be considered due to following delays:serialization, packetization, coder, and propagation, dejitter buffer and procesing.

5. Conclusion

This paper has discussed the implementation of real test bed dual stack tunnelling over IPv6 in comparison to IPv4. The overall result from the test shows that, there is a slight but significant difference in file transfer performance between dual stack tunnelling IPv4 and IPv6 protocol. Small size file transfer (5MB and 10MB) will result in lower and same delay performance for IPv4 and IPv6. Finally, it is found that large size file transfer (90MB and 100MB above) over IPv6 will result higher level of delay in performance in comparison to IPv4. We can conclude that based on our findings; FTP over IPv6 will slightly lower file transfer performance.

For future work, the study will focus on several techniques and to analyze the performance of file transfer over wireless IPv6 environment as follow: i) queuing; ii) congestion avoidance; iii) header compression; iv) RSVP; and v) fragmentation. Besides, these suggested techniques might be able to increase file transfer performance in wireless IPv6 protocol environment such as: **i) Compression:** Reduces serialization delay and bandwidth required to transmit data by reducing the size of packet headers or payloads **ii) Link Efficiency:** Used to improve bandwidth efficiency through compression and link fragmentation and interleaving.

References

[1] Daniel Collins. (2002). Carrier Grade Voice over IP, 2nd Ed, McGraw-Hill, September.

[2] Baset, S. A., Schulzrinne, H. (2006). An analysis of the Skype peer-to-peer internet telephony protocol, *In*: Proc. Of IEEE INFOCOM, Barcelona, Spain, Apr.

[3] Markopoulou, A., Tobagi, F., Karam, M. (2002). Assessment of VoIP quality over Internet backbones, *In*: Proc. Of IEEE INFOCOM, New York, NY, Jun.

[4] Chen, K., Huang, C., Huang, P., Lei, C. (2006). Quantifying Skype user satisfaction, *In*: Proc. Of ACM SIGCOMM, Pisa, Italy.

[5] Chiang,W., et al. (2006). A performance study of voip applications: Msn vs. skype, *In*: Proc. Of MULTICOMM.

[6] Sat, B.,Wah,W. (2006). Analysis and evaluation of the Skype and Google-Talk VoIP systems, *In*: Proc. IEEE Int'l Conf. on Multimedia and Expo, July.

[7] Lambrinos, L., Kirstein, P. (2007). Integrating voice over IP services in IPv4 and IPv6 networks, *In*: Proceeding ICCGI' 07, p. 54-59 March.

[8] Yasinovskyy, R, Wijesinha, A. L., Karma, R. K., Khaksari, G. (2009). A Comparison of VoIP Performance on IPv6 and IPv4 networks, AICCSA, IEEE/ACS International Conference on Computer Systems and Applications, p. 603- 609.

[9] Xiaoming Z., Henk, U., Rob, E. K., Piet, V. M. (2006). Estimation of perceived quality of service for applications on Ipv6 networks, *In*: Proceedings of the ACM international workshop on Performance monitoring, measurement, and evaluation of heterogeneous wireless and wired networks, Terromolinos, Spain, p. 74 – 81.

[10] Cole, R. G., Rosenbluth, J. H. (2001). Voice over IP Performance Monitoring, SIGCOMM Computer Communication Rev., 1 (2) 9-24.

[11] Zhou, X., Jacobsson, M., Uijterwaal, H., Van Mieghem, P. (2006). Ipv6 Delay and Loss Performance Evolution, submitted to *International Journal of Computer Networks*.

[12] Zeadally, S., Raicu, I. (2003). Evaluating Ipv6 on Windows and Solaris. *IEEE Internet Computing*, 7 (3) 51-57. June.

[13] Mohamed, S. S., Abusin A.Y. M., Chieng, D. (2005). Evaluation of IPv6 and comparative study with different operating systems, *In*: proceeding ICITA'05, 2, p. 665-670, July.

[14] Zeadally, S., Raicu, I. (2003). Evaluating IPv6 on Windows and Solaris, *Internet Computing*, 7 (3) 51-57, May/June.

[15] Rosilah, H., Mohd Khairil, S. End-to-end baseline file transfer performance testbed, *Information Technology Journal*, 10 (2) 446-451.

[16] Samer, S., Hassan, Rosilah H. (2011). IPv6 Network Mobility Route Optimization Survey, *American Journal of Applied Sciences*, 8 (6) 579-583.

[17] Ping, L., Subramoni, H., Narravula, S., Mamidala, A., Panda, D.K. (2009). Designing Efficient FTP mechanisms for high performance data-transfer over infiniband. *In*: Proceedings of the International Conference on Parallel Processing, Sept. 22-25, *IEEE Computer Society Washington*, DC, USA., p. 156-163

[18] Li, B., Lin, H., Sohraby, K., Wang, C. (2010). Future internet services and applications. *IEEE Network J*., 24: 4-5

[19] Vaughan-Nichols, S. J. (2010). Will HTML 5 restandardize the web. *IEEE Comput. J*., 43, p.13-15